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Recent Advances in Future Mobile Multimedia Networks

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1. Introduction

The increase in the number of wireless devices and multimedia applications, coupled with the desire to connect them to the ever-growing Internet, is leading to a mobile multimedia Internet, where the support for the mobility of devices will soon be taken for granted. In addition to the global connectivity support, it is also expected that the management of intra and inter-domain handovers (heterogeneous scenarios), in a seamless and multimedia-awareness manner, is a way to increase user satisfaction and profits for mobile multimedia providers. However, heterogeneous wireless network structures, severe channel impairments, unavailable multimedia quality level controllers and complex traffic patterns make mobile scenarios much more unpredictable than wired networks.

Existing mobility control proposals, such as Mobile IP version 4 (MIPv4) Gunasundari & Shanmugavel (2009) and MIP version 6 (MIPv6) Dinakaran & Balasubramanie (2011), Hierarchical MIPv6 (HMIPv6) Harini (2011), Fast Handovers for IPv6 (FMIPv6) Zhang & Pierre (2009), bi-directional tunnelling based on MIP, and the remote-subscription technique were developed to control mobility applications in homogeneous networks. Other recent wireless access technologies, based on IEEE 802.11 De Moor et al. (2010), IEEE 802.16 Ahmadi (2009) and LTE Ergen (2009), aim to provide handovers, but fail in the Quality of Service (QoS), Quality of Experience (QoE), and in seamless heterogeneous support.

With regard to heterogenic control, the IEEE 802.21, wherein is proposed the Media Independent Handover (MIH) Taniuchi et al. (2009), enables vertical handover, detects target networks in advance, and allows the integration and seamless mobility among heterogeneous systems. Recent advances in wireless radio resource management, as proposed by the IEEE 802.11k Meschke et al. (2010) Working Group, are aimed at improving the distribution of multimedia content within a network, where the mobile user can connect to the access point (AP) that provides the best QoS/QoE support and not only the strongest signal. Other approaches have been proposed to support seamless mobility for multimedia applications, such as pre-fetch and cache-based multimedia schemes, self-adaptive handover management solutions for mobile streaming continuity, and content-oriented mobility schemes. For example, the last application mentioned performs handovers, by exploring the characteristics of the available wireless resources, predicted user perception, and on-going multimedia content.

To follow, a traditional handover process is described where two MIP (v4 and v6) are designed for network-layer handover and hide mobility from upper layers. On a macro movement (Layer 3 handover), a Foreign Agent (FA) or a Dynamic Host Configuration Protocol (DHCP) server distributed an FA Care-of-Address (CoA) or a uniquely put CoA to a mobile device. The mobile device then performs location update at its Home Agent (HA) with the latter binding between its Home Address (HoA) and CoA. When a Correspondent Host (CH) sends data packets of the mobile device to the HoA, its HA receives the packets and tunnels them to the CoA.

Afterwards, the FA or the MH itself decapsulates the tunnelled packets, depending on the CoA type. If MIP with Route Optimization (MIP-RO) Shahriar et al. (2010) is applied, the HA may send a Binding Update (BU) message to the CH on intercepting the first incoming packet. This functionality allows the CH to tunnel directly the following session packets to the CoA associated with the mobile device. However, as presented, it is evident that novel mobile multimedia mechanisms are needed to provide seamless, QoS/QoE, green communication, cross-layer and multimedia-awareness in future heterogeneous multimedia networks Seshadrinathan & Bovik (2011).

In future mobile multimedia systems, it is very important to develop (or extend) novel handover controllers to allow intra and inter mobility, while keeping ongoing mobile applications with an excellent quality level and optimizing the usage of wireless resources. The base station selection procedure should be done, by controlling and adapting QoE performance indicators which represent service integrity, such as throughput, delay, jitter, packet loss, bit error rate (BER), peak signal-to-noise ratio (PSNR), structural similarity (SSIM), video quality metric (VQM), and mean opinion score (MOS)-related metrics Zinner et al. (2010). In addition, buffer and caching mechanisms, together with mobility prediction and session context transfer approaches, must be integrated in order to provide seamless mobile multimedia handover in future wireless networks Klein & Klaue (2009) Zhou et al. (2010).

To conclude, an overview of the most relevant challenges and trends for future mobile multimedia networks will be addressed, Mobility was concentrated in the k, v, and r mechanisms of the IEEE 802.11 standard, heterogeneity and quality level support. These will be discussed in detail. Moreover, seamless handover and user experience mobility approaches will be presented in the context of future Internet scenarios. In order to introduce the benefits of traditional and novel mobile multimedia solutions, simulation experiments will be carried out to demonstrate the impact of handover schemes on the performance of the networks.

2. Design of Mobile IP

The IP Mobile is a standard protocol which aims at connectivity to the level of the IP layer, irrespective of the physical location of the mobile gadget. A node in the roaming may have access to the internet by the encapsulation of its data through the IP protocol, without, however, changing the IP address of its home network, leaving the mobility transparent for the application and protocols of the layer TCP and UDP of transport.

Before mobility of IP the users of mobile nodes had to be satisfied entirely with the portability of the equipment. This is because at first when a node was moved from one network to another, the data transactions which had access were interrupted and a new data transaction with a NE network was initiated. With the coming of the MIP a node can have almost uninterrupted and continual connectivity with the applications provided it among the networks keeping its original IP address.

One of the main technical problems that have to be dealt with for mobility support is the manner in which the addressing IP has to be used. The Unicast internet traffic is routed to a specific locality in the field of the address destination of the IP header. The IP destination address specifies the address for the networks and , therefore, the traffic it is carrying for this network. This is not appropriate for the mobile noder, which wants to mantain its original IP address irrespective of its present location and without that of the internet network node. The MIP resolved the problem by making the mobile node use two IP addresses, the home Address (HA) and Foreign Agent (FA), as shown in Figure 1.

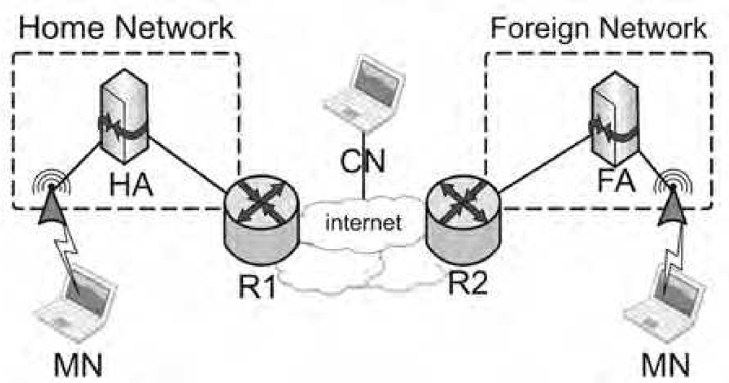

Fig. 1. Basic Topology of MIP

The Mobile IP was conceived to allow the movement of nodes from one IP subnet to another. Although its arquitecture suits this purpose, the process of transition from one node among IP subnets with the change in the access point, called handoff or handover, presents two factors which harm the applications in real time, i.e. interactives or those sensitive to delays. The first is a great latency in the process, which generates a long period of time without receiving the packages. The second refers to the great number of discarded or delayed packages due to the change in the point of access.

2.1 Mobile IPv4 overview

The Mobile protocol IP4 (MIPv4) was proposed by the IETF work group in Mobile IP. The mobility of IP in the IPv4 as specified in Gunasundari & Shanmugavel (2009), has objectives such as presenting the functional entities of the MIPv4(MobileIPv4), presenting support operations for mobility, presenting the extensions for the optimizing of the routing of the MIPv4 (Mobile IPv4) and identifying the problems which affect communication during the handover.

2.1.1 Functional entities of the MIPv4

The Mobile IP is formed by the following functional entities Le-Trung et al. (2010):

1. **Mobile Node (MN):** represents a host or a router that alters its point of access when it migrates from one network or subnet to the other. It can change location without modifying its IP address and may continue to communicate with other nodes of the internet in any place using its IP address (constant), assuming that a connection of the level of the looping to an access point is available.

2. **Home Agent (HA):** represents a router in the home network (HN) of a MN that does tunneling of datagrams in order to deliver to the MN when it is away from home, in addition to keeping information on the actual location of the MN.
3. **Foreign Agent (FA):** represents a router in the network visited by the MN, also known as the foreign network, which provides the service of routing to the MN while it is registered. The FA delivers to the MN datagrams received through the tunnel configures with the HA. For the datagrams sent by the MN, the FA can serve as a default router for registered MNs.

Apart from these entities, the hosts with which the MN communicates are known as CNs. These hosts can be movable or stationary.

2.1.2 Optimizing of routing for the MIPv4

As specified in Shahriar et al. (2010), the extensions of routing optimizing offer provide means for the nodes to make cache binding of the MN. Mobility binding is mobility information associated to the MN, such as HA and CoA. This then tunnels its own datagrams directly to the CoA indicated by the binding, thus diverting the traffic of the HA to the MN. These extensions also make it possible for the datagrams in transit to move and the datagrams sent based on an invalid binding to be sent directly to the MN in its new CoA. The routing optimizing is divided into two parts, updating of the cache binding and management of the smooth handover among FAs.

In relation to the cache binding, each of the nodes has the means of maintaining a cache and CoA binding containing a CoA of one or more MNs. When it sends a datagram to an MN, if there has been an entry in the cache binding to the MN destination, the datagrama can be tunneled directly to the CoA indicated in the cache binding. In the absence of an entry, the datagramas destined for the MN must be routed to the HN of the MN in the traditional way of IP routing, then to be tunneled by the HA to the CoA of the MN. These entries have an associated valid time limit that is specified in the Binding Update message received by the node for updating the cache binding. After the validity has expired the binding is erased from the cache.

2.1.3 Handover in the MIPv4

The handover in the MIPv4 is typically determined when the MN receives a new Agent Advertisement message. When in a new FN, the MN executes the standard procedure for registering of the new CoA in its HA. The register is done through the exchange of RR and RR messages, via FA or directly ,depending on the CoA obtained. When the register is completed , the HA cancels the tunnel established with the former CoA, in order to establish a new tunnel with the new CoA. After this process, the HA begins to send the datagrams destined for the MN via the new tunnel.

Although the handover occurs in a manner which maintains communication between the MN and the CNs, this process does not cater for the characteristics of the real time and sensitive applications to the delays due to the latency of the process itself Le-Trung et al. (2010).

The latency in detection of the movement is due to the necessity to detect the movement in a reliable way for the new network (without the ping-pong effect). This occurs as a result of the frequency of messages announcing routers, as well as their range.

The latency in obtaining the CoA depends on type of CoA obtained. If the collocated CoA mode was utilized, together with DHCP, the latency will be high and unacceptable. The latency of the process occurs due to the necessity of exchanging signal messages with external components of the network.

The delays associated with the operations of the looping layer are specific to the technology used and contribute to the performance of the handover. For example, in the IEEE802.11, the handover operation typically involves sweeping of the access points in all the channels available. The selection of the appropriate access point, and its association with this access point, may even involve access control operations as specified in the IEEE802.1x De Moor et al. (2010).

Another factor which jeopardizes some applications during the handover is the loss of datagramas. In the MIPv4, the MN remains without receiving datagrams until the registration procedure is completed and the tunnel between the HA and the new CoA is established. Once this exists, during the time of the process described, there occurs a complete loss of datagrams in transit through the tunnel established between the HA and the former CoA.

Even with the utilization of the smooth handover, as the datagrams in the optimization of the MIPv4, MN remains without receiving the datagrams until the notification of the binding update is sent to the former FA and the tunnel between the former FA and the new CoA is established for sending the datagramas. Thus being the case, during the time of the process described, there occurs a partial loss of datagrams in transit through the tunnel established between the CN and the former FA.

2.2 Mobile IPv6 Overview

As presented in Dinakaran & Balasubramanie (2011), the support to the IP mobility in the IPv6 (Mobile IPv6) has benefitted from the experiences obtained in the development of the MIPv4 (MIPv4) and from the facilities provided by the IPv6. For this reason, the mobile IPv6 shares many operational characteristics of the Mobile IPv4. However, it is integrated to the IPv6 and offers other improvements. Some of the main differences between the MIPv4 and MIPv6 are listed below:

2.2.1 Functional entities of the MIPv6

The mobile MIPv6 is formed by the same functional entities defined in the MIPv4, with the exception of the FA. As stated Yu et al. (2008), any IPv6 router with a foreign link can function as a default router of the MN in a foreign locality. This router is responsible for providing the prefix of the foreign network and the Care-of-Address CoA for the MN. There is not any special configures requirement for the router, as this is merely a routable unicast address associated to the MN during its visit in the foreign link whose subnet prefix of the IP is a prefix of the foreign subnet CoA an equivalent to the collocated Care-of-Address of the MIPv4). In particular, the CoA registered in the HA of the MN is associated with its home address, being called the primary Care-of-Address.

2.2.2 Routing optimizing for the MIPv6

The optimizing of the routing requires that the MN register its current binding in the CN. For this it is necessary that the CN supports mobility binding and that the MN executes the registry procedure in the appropriate manner. As part of this procedure the test called Return Routability, which is described in Yu et al. (2008), must be executed to authorize the configures of the binding. This test supplies necessary security information to the MN to build a binding update message that must be sent to the CN to update the binding of the MN.

In the routing optimizing mode , the packets of the CN can be routed directly to the CoA of the MN. When packets are sent to any IPv6 destination, the CN searches for an entry into its cache binding destination address for the packet. If this is found the node utilizes a new IPv6 routing header, called type routing header Yu et al. (2008), to rout the packet to the MN through the CoA indicated in the binding. For correct routing the CN fills out the destination address in the IPv6 header with the CoA of the MN and the new type of header with the home address of the MN. This router shortens the communication means being used and also eliminates congestioning in the HA of the MN and in the home link. Even as a consequence, the impact of possible failures associated with the HA or with the networks on route between the MN and the HA is reduced.

In a similar way the packets of the MN can be routed directly to the CNs. For this, the MN fills out the original address of the IPv6 header of the packet with its CoA and the destination address with the address of the CN. Following this, the MN adds a new option, called IPv6 home address destination to carry its home address. The inclusion of the home address in these packets makes the use of CoA transparent to the layers of upper networks (for example, at the level of transport).

The MIPv6 also offers support to the multiple HAs, and limited support for reconfigures of the HN. In these cases, the MN cannot know the IP address of its own HA, and even the prefixes of the home subnets can change over time. One known mechanism, such as dynamic home agent address discovery allows for a MN to dynamically discover, the IP address of a HA in its home link even when the MN is outdoors. The MNs also can learn new information on the prefixes of the home subnet through the mobile prefix discovery mechanism.

2.2.3 Handover in the MIPv6

The MIPv6 Yu et al. (2008) specification considers the primary objective of movement detection is to detect handovers of the third level (L3 handovers) describing a generic method which utilizes the facilities of the IPv6 Neighbor Discovery Dinakaran & Balasubramanie (2011), including the Router Discovery and the Neighbor Unreachability Detection.

This generic detection of movement utilizes the Neighbor Unreachability Detection to detect when the default router is unreachable in a bidirectional manner, the moment in which the MN must discover a new router (usually in a new link). However, this detection only occurs when the MN has packets to send. This being the case, in the absence of a continual message of router advertisement or indices of the data link layer, the L3 handover can be noticed by the MN. For this reason, it is recommended that the MN supplements this method with some other information whenever the it is available (for example, from the protocols of the lower layers).

When a L3 handover is perceived, the MN must execute the Duplicate Address Detection procedure Dinakaran & Balasubramanie (2011) for its local link address, select a new router with the Router Discovery procedure , and then execute the Prefix Discovery procedure with the new router in order to form the new CoA. After this, the MN must register the new CoA primary with the HA in order to update its information mobility (mobility binding) of the CNs which operate in the same routing optimization mode.

Just as with the MIPv4 , although the handover occurs in a manner that maintains communication between the MN and the CNs, this process does not address the characteristics of the real time and sensitive applications to the delays, for the same reasons already explained for the MIPv4, in other words, its great latency.

The loss of the datagrams during the handover also occurs in a similar manner to the MIPv4. In the tunnel bidirectional mode of operation, the MN remains without receiving datagrams until the registration procedure is completed and the bidirectional tunnel between the HA and the new CoA is established for the sending of datagrams. Thus being the case, during the time of the process described , there occurs the complete loss of datagrams in transit through the bidirectional tunnel established between the HA and the old CoA.

Even with the utilization of the routing optimization mode of operation the MN remains without receiving datagrams, until the Binding Update notification is sent to all the CNs. Thus, until the updating of the mobility binding, associated with the MN in the CNs, there occurs a complete loss of datagrams sent by the unupdated CNs with the old CoA.

In light of these exposed problems, the scientific community seeks to improve the support for mobility in the IP through optimization proposals which come to reduce the loss of datagrams and the latency of handovers, thereby minimizing the time without receiving datagrams, with the objective of offering a transparent handover (seamless handover).

2.3 Optimizing for the handover

As stated before, one of the problems affecting MIPv4 and MIPv6 communication is the latency as it relates to rendering the new CoA register effective. This operation is slow because it involves the exchange of signal messages with components outside the network, particularly with the HA and with the CNs that support routing optimization.

Here is presented some of the main optimizations proposed for the MIPv6. The main objective of these proposals is to minimize the latency of the handover and to reduce the delay and the loss of datagrams during this operation. In a general way the proposals seek solutions for: i) minimizing the register time for CoA; ii) minimize the time for changing the access point; iii) to avoid delays and loss of datagrams.

The hierarchical handover scheme described below was defined for the MIPv4, as was presented in Romdhani & Al-Dubai (2007) and will not be presented here.

2.3.1 Hierarchical Mobile IPv6 Mobility Management (HMIPv6)

The hierarchical handover scheme divides mobility into two categories, with the aim of minimizing the latency, being the primary layer of micromobility (generally intra-domain)and the second layer being the macromobility (generally inter-domain). The central element of this scheme is the entity concept called Mobility Anchor Point (MAP) Pack et al. (2007), that defines a domain MAP formed by one or more networks. The movement of a MN between networks of the different MAP domains determines a macromobility.

Each of the networks of a MAP domain has an Access Router (AR) which corresponds to the router default of the MNs in its reachable (scope) region. The presence of the MAP domain to which the AR belongs is announced in a message of Router Advertisement. Thus, the change of a MAP domain is perceived by the MN when a new advertisement with information from a new MAP is received by the MN.

As specified in Khan & Rehana (2010), in a new MAP domain, the MN makes a binding of its CoA obtained in the local network, known as Local CoA (LCoA),with an address in the subnet of the MAP, known as Regional CoA (RCoA), and that usually is the address of the very MAP. Acting with a local HA, the MAP intercepts all the packets destined to the MN and encapsulates them and sends them directly to the LCoA. If the MN changes to another network of the same domain MAP only the register of the new LCoA is made, together with MAP with a binding update message. And then, only the RCoA needs to be registered, through another binding update message, in the HA and in the CNs with which the MN communicates. This RCoA is not modified if the movement of the MN is along the same MAP domain. This makes the micromobility of the MN transparent in relation to HA and the CNs. Figure 2 illustrates the hierarchical MIPv6 scheme.

With the objective of accelerating the handover between MAPs and reducing the loss of packets, the MN must send a binding update message to its previous MAP, specifying its new LCoA. The packets that were in transit to the previous MAP will then be passed on to the new LCoA. It is also allowed that MNs send binding update messages containing the LCoA (instead of the RCoA) to CNs which are present in the same network visited. In this way the packets will be routed directly without crossing the MAP.

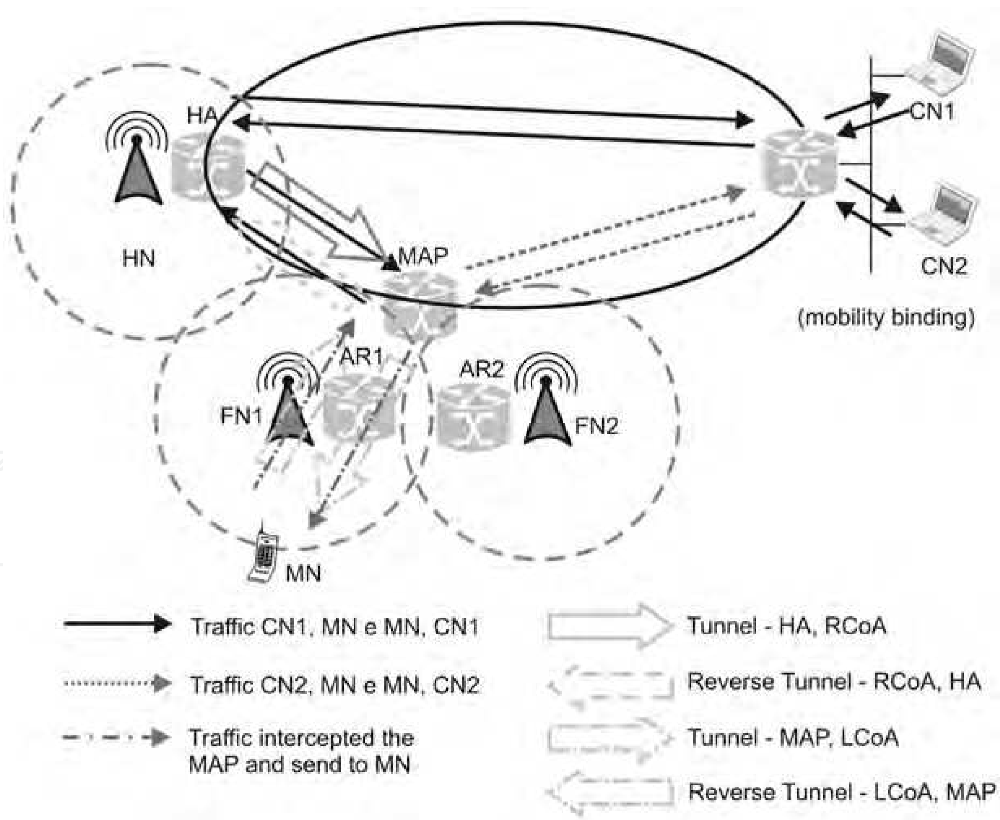

Fig. 2. Hierarchical MIPv6 Scheme

2.3.2 Fast handovers for Mobile IPv6 (FMIPv6)

As described in Han et al. (2007), the ability of immediately sending packets from a new subnet link depends on the latency of the IP connectivity, which itself depends on the latency of movement detection and the latency of configures of the new CoA. Once the IP capacity of the MN is restored the binding update message can be sent to its HA and all the CNs. From the successful processing of the binding update by its CNs, which typically involves the execution of the return routability procedure Yu et al. (2008), the MN can receive packets of the new CoA. Thus, the ability to receive new packets from the CNs directly to its new CoA depends on the latency of the binding update and the latency of the IP connectivity.

The protocol defined in Tabassam et al. (2009) makes it possible for the MN to rapidly detect its movement to a new network as it supplies information on the new Access Point (AP) and on the associated subnet prefix while the MN still finds itself connected to its actual subnet, whose default router comes to be called the Previous Access Router (PAR). For example, a MN can discover the available APs using mechanisms of the data link layer (for example, scan operation in WLAN) and then request information from the corresponding subnet to one or more of the APs discovered. This requisition is done with the sending of the Router Solicitation for Proxy Advertisement (RtSolPr) to its access router.

The result of the identifier resolution associated with an AP is the tupla [AP-ID, ARInfo], where AP-ID is the AP identifier and AR-Info is composed of the L2 address of the router, IP address of the router and a valid prefix in the subnet to which the AP is connected. This response is sent by the AR to the MN in the Proxy Router Advertisement (PrRtAdv) message.

With the information obtained, the MN formulates a secondary new CoA (NCoA) and sends an AFSt binding update message (FBU) when a specific handover link event occurs .This message has the purpose of authorizing the PAR to make PCoA binding (Previous CoA) for the NCoA, in a way that the packets which arrive could be tunneled to the new MN location. Whenever possible, the FBU must be sent from the PAR link. When this is not possible the FBU is sent from the new link. With the execution of this procedure the latency related to the discovery of the new prefix subsequent to the handover is eliminated. As confirmation of receipt of the FBU, the PAR must send the Fast Binding Acknowledgment (FBack) message, whether or not the FBack message is received in the previous link. The scenario in which the MM sends a FBU message and receives a FBACK message in the PAR link is characterized as an operation in pre-indicated mode or anticipated (predictive), as illustrated in Figure 3.

The scenario in which the MN sends a FBU message from the NAR link is characterized as an operation in the reactive mode, as is illustrated in Figure 4. This mode also deals with cases in which the FBU message is sent from the PAR link , but a FBack message was not yet received.

Finally, the PrRtAdv can be sent unsolicited, i.e. without a previous RtSolPr message. This operation makes it possible for the MN to be kept informed about the geographically adjacent networks, thus reducing the quantity of traffic necessary to obtain the topological map of the neighborhood links and subnets. Nevertheless, the HI and HACK messages can still be utilized for transference of relevant information in the context of the network, such as access control, QoS and header compression along with the handover.

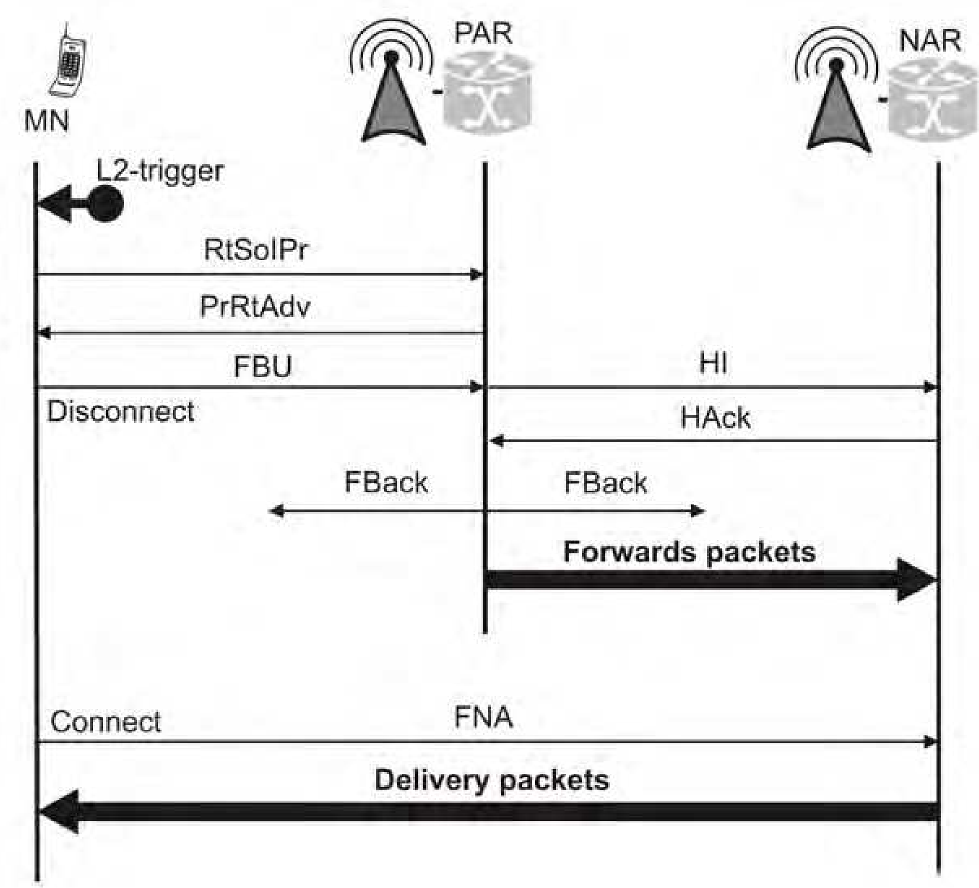

Fig. 3. Fast Handover: operation in the pre-indicated or anticipated mode

2.4 Media Independent Handover - MIH

The Media Independent Handover (MIH) IEEE 802.21 Draft Standard defines methods and specifications for transparent handovers in layer 2 (Handover L2) among networks with different technologies Taniuchi et al. (2009). The envisaged standard helps in the determination and initialization of a handover, but leaves unspecified details about how to treat the handover.

In order to provide such functions, the IEEE802.21 defines the MIH Function (MIHF) positions between layers 2 and 3, which offer three basic services: i) Events Service, through the Media Independent Event Service (MIES); ii) The Command Service, through the Media Independent Command Service (MICS); and iii) The Information service, through the Media Independent Information Service (MIIS). The architecture of the MIHF is illustrated in Figure 5.

The MIES supplies a classification of events, filtering of events and a report of events that correspond to the dynamic changes which occur in the link in relation to characteristics, state and quality. As shown in Figure 6, the MIH Function must be registered in the data link layer in order to receive the link events, while the upper links interested in MIH events must be registered in the MIH Function to receive these events. The events can be generated by remote battery of the Point of Access (PoA) which is acting as a Point of Service (PoS). The link events and MIH events are divided into five categories: administrative, change of state, link parameter, pre-indicated (predictive) link synchronization, and link transition.

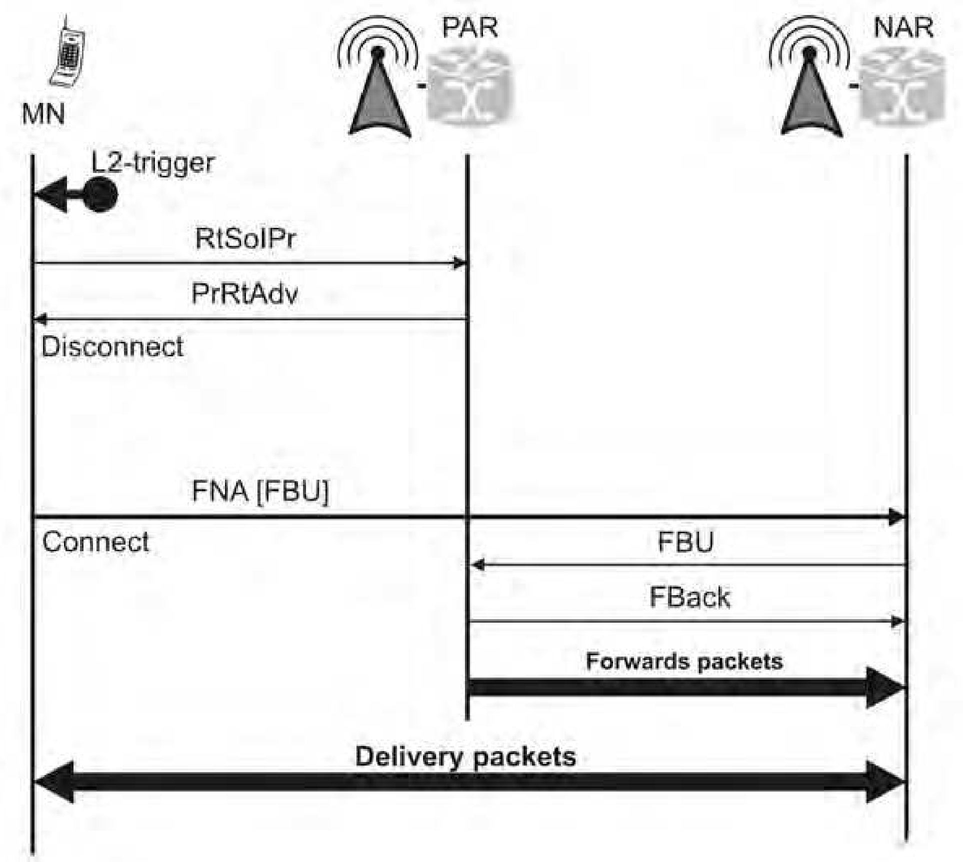

Fig. 4. Operation in the reactive mode

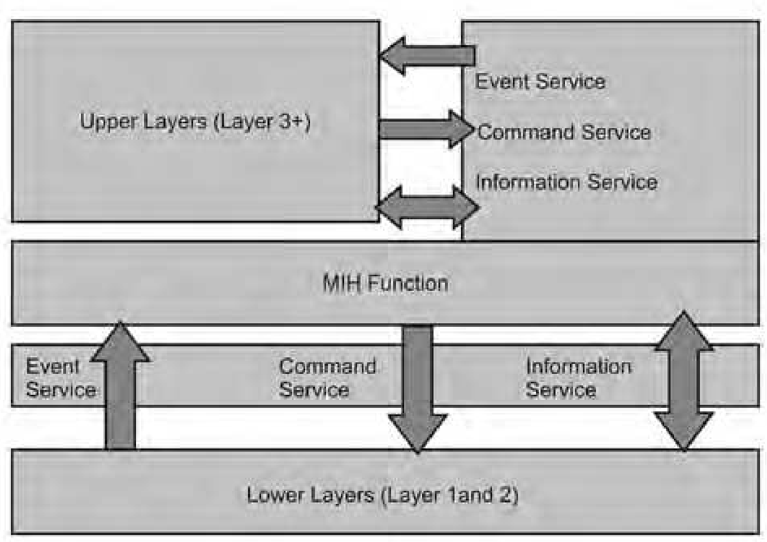

Fig. 5. Architecture of MIH Function

The MICS allows MIH users to be able to manage and control relevant link characteristics for handover and mobility. As illustrated in Figure 7, the MIH commands originate in the upper layers in direction to the MIH Function. In this, these commands become a remote MIH command for a remote battery and/or follow the lower layers as a link command of the MIH Function. The link commands are specific to the access network in use and are only local.

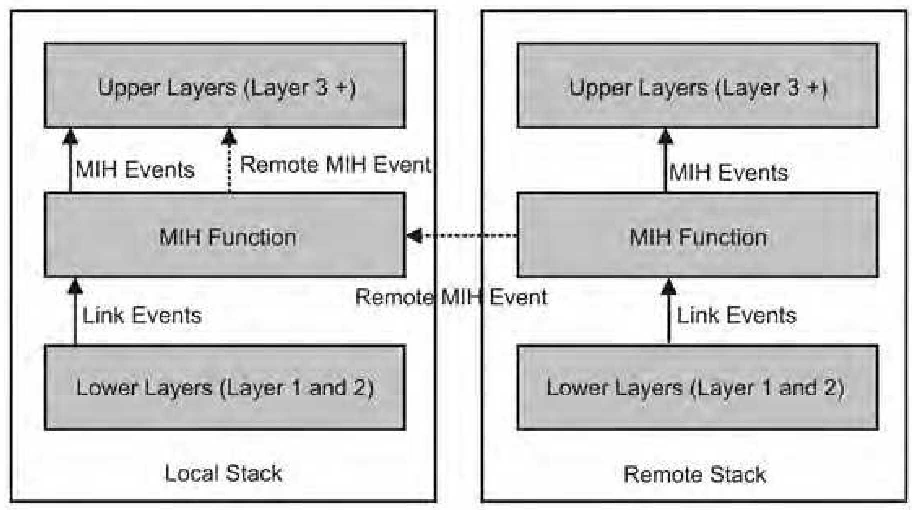

Fig. 6. Functioning of the MIES

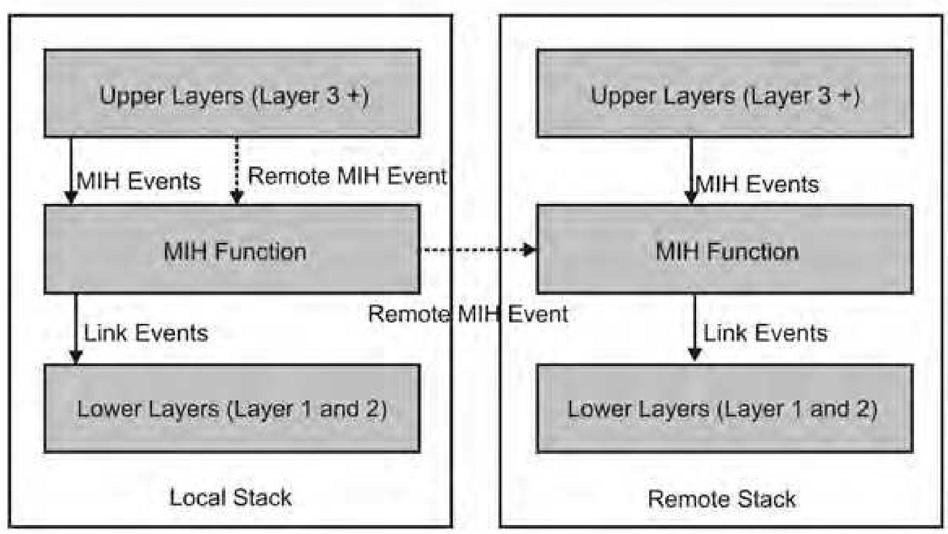

Fig. 7. Functioning of the MICS

The MIIS provides the capacity to obtain information necessary for the handovers such as neighborhood maps, information about the data link layer and available services. In short, this service offers a two-way route for all the layers to share Information elements that help in the handover decision-making process. These information elements are divided into five groups: General Information (e.g. area operators); Network Access (e.g. cost, security, QoS); Information on PoA (e.g. information about the subnet); and Other Information (e.g. specific to the supplier).

3. Wireless networks and multimedia communications

The networks of the next generation, such as the fourth generation wireless networks (4G), represent a total convergence of voice and data. There is also consideration of the convergence of wireless networks such as the standards (IEEE 802.11; IEEE 802.16; IEEE 802.15.4; IEEE 802.22; 3GPP-LTE; 3G; and G4), and of the integration of fixed and mobile networks.

3.1 Wireless networks

According to the Institute of Electrical and Electronics Engineers (IEEE) Wireless networks are classified into Wireless Personal Area Network (WPAN); Wireless Local Area Network (WLAN); Wireless Metropolitan Area Network (WMAN); and Wireless Regional Area Network (WRAN). For each classification IEEE defines the parameter standard. A different set of characteristics are included in the technologies of each determined wireless network service. These technologies were described in the above classification. Thus each classification needs to work with its specific IEEE standard as these are the standards which represent the classification.

3.1.1 The IEEE 802.11 Standard

When one uses mobility in the IEEE802.11 standard for WLAN network infrastructure the connection point of the device for the Internet network remains the same during its mobility. This means that a mobile node dislocating itself within its own network, with various points of connection making use of the same configures parameters, can have its data received in that new location De Moor et al. (2010). This mobility seeks to increase the action raduis of a node within a determined area (intra-domain). Over time, and like the other standards, the 802.11also experienced evolutions from which emerged the k, v, and r standards that will be mentioned below.

1. **The IEEE 802.11k Standard**
   The k extension of the 802.11 standardizes various types of information on characteristics of the 802.11 radio which can be measured, as well as the messages used in these, and allows transparent transitions of the Basic Set of Services (BSS). This standard also implements QoS. The main objectives of the 802.11k extension are Yu et al. (2008) Hermann et al. (2007):
   - To allow the station to measure the specific parameters of the 802.11radio;
   - To standardize requisitions and report messages with the results of these measures; and
   - To make available access of this information to all the upper layers of the pile of protocols.
2. **The 802.11v Standard**
   The v extension of the 802.11 is characterized by the management of wireless networks, and allows the configures of devices of clients connected to the networks similar to those used in mobile networks IEEE802.11v (2011)Ciurana et al. (2011).
3. **The 802.11r Standard**
   The r extension of the 802.11, standardizes rapid handover when a wireless client associates with another AP in the same network during a locomotion process Khan & Rehana (2010) Tabassam et al. (2009).

3.1.2 The IEEE 802.16 Standard

The IEEE 802.16 Standard defines, among other characteristics, the air interface specification, the additional functionalites in the physical layer, and the changes in the layer of access control of the device for metropolitan wireless networks, also known as fixed systems, without broad band connection Li et al. (2007). The system, based on the 802.16 standard, is basically composed of a base station and terminal stations, known also as CPE (Customer Premises

Equipment). A station base is the central place that collects all the data of and for the terminal stations within a cell. The station bases have antennas with relatively wide beams, divided into one or various sectors to supply 360 degree coverage. A subscriber unit, or CPE, consists basically of an external unit with a radio and an antenna connected to an internal unit, basically a modem, which makes the interface with the end-user.

3.1.3 The IEEE 802.15.4 Standard

The IEEE 802.15.4 Standard, called Low-Rate Wireless Personal Area Networks (LR-WPAN), has as its objective to establish a network with characteristics of low complexity, low costs and low energy consumption Ramachandran et al. (2007).The scope of this standard is to define the physical layer and sub-layer of access control of the MAC device, as the IEEE 802 workgroups traditionally do in network solution standards.

3.1.4 The IEEE 802.22 Standard

The development of the IEEE 802.22 standard (WRAN), destined for the use of cognitive radio technology, is to allow for the sharing of locally idle spectrum attributed to the TV diffusion service in a regime of non-interference, and to take wideband access to regions of difficult access, areas of low population density, and rural environments. For this it is timely and has the potential for ample applicability in the whole world Stevenson et al. (2009).

3.2 Multimedia communications

The applications for Long Term Evolution (LTE) Ergen (2009), third-generation (3G) and fourth-generation (4G), have presented increasing integration and convergence of multimedia services linked directly the increase in demand for data and mobility. As a result the 4G technology is gaining much attention.

4G environments are a fully integrated all-IP packet-switched system that promises to support the following features: a highly efficient spectral system, support for all types of multimedia content, access speeds up to 1 Gigabit/second for low mobility, such as local wireless access, and up to 100 Mbits/s for high mobility, such as vehicular scenarios, seamless handoff and global roaming across multiple heterogeneous networks, better scheduling and call admission control schemes, terminal heterogeneity, and several other interesting features Tong et al. (2008).

In addition, 4G networks also provide high usability for end users, enabling them to customize their multimedia applications and receive their content with QoE assurances. 4G systems are expected to play a fundamental role in supporting truly ubiquitous multimedia communications in coming years. However, to satisfy the skyrocketing demand for multimedia service access over heterogeneous wireless network infrastructures at any-time, from anywhere and any device, several challenges need to be addressed at the network, device, and application levels.

It is well known that multimedia transmissions over wireless communication links need to also take into account the characteristics of the links in contrast to wired networks. Packet losses in wired networks are primarily due to congestions, whereas in the case of wireless networks they are caused mainly by corruption of packets due to low Signal to Noise Ratio (SNR), interferences from nearby transmissions, or multi-path signal fading Bouras et al. (2008). Past efforts to mitigate delays and packet losses caused by wireless links have primarily focused on cross-layer design optimization techniques, where dependencies between protocol layers are exploited to improve the end-to-end performance delivered to end-users. Some of the recent cross-layer design architectures that have been proposed specifically for multimedia transmissions include Huusko et al. (2007)Bobarshad et al. (2010). Most of these cross-layer approaches provide additional support through the implementation of new interfaces used for sharing information between adjacent layers or by adjusting parameters that span across different transmission layers.

The layers exploited by several proposed cross-layer designs typically involve all or a subset of the application layer (even a user-based layer), the Media Access Control (MAC) layer, and the physical layer. For instance, proposed a cross-layer design aimed at improving the quality of H.264 video over IEEE 802.11e-based networks Chilamkurti et al. (2010). The design takes advantage of the characteristics of both application and MAC layer information to improve the video transmission quality of H.264 video. As described in Kovács et al. (2010) proposed an approach that classifies multimedia packets into different classes, and depending on the underlying network conditions, only specific packets are transmitted. Their cross-design approach also exploits information from the MAC layer and the transport layer to optimize MPEG-4 video delivery and quality. Several other multimedia cross-layer designs for multimedia transmissions using different types of adaptation strategies (such as the integrated, the MAC-centric, or the top-down approaches) have been proposed in the literature.

Advances in wireless QoS/QoE models and portable devices have been allowing the distribution of high quality multimedia content to fixed and mobile users. New strategies in routing, admission control, resource reservations, re-registration, and authorization, among others have been discussed in literature and implemented by service providers, and are creating ubiquitous wireless multimedia systems.

In addition to network-based efforts, mobile wireless devices are also attracting a lot of attention. Nowadays, it is possible to see fairly complex multi-function terminals capable of handling different media types. Mobile users are using such devices for different purposes, including the storage of personal information (e.g., an address book), to conduct various forms of interactions (e.g., voice, email, video phone), entertainment (e.g., gaming, on-demand video streaming), and information access (through web browsers) Cerqueira et al. (2008).

Wireless multimedia devices are placing increasing demands on designers and manufacturers to provide higher processing capabilities, a larger number of functions and usage modes, displays with higher resolutions, user-friendly/multimodal interaction modes, and the support of multiple wireless interfaces that can connect to different types of wireless networks. In the context of future multimedia systems, fast detection of available access networks and selection of the "most appropriate" network interface based on factors such as user preference, costs, seamless and application requirements are becoming increasingly important for many portable devices.

Another important design consideration for future mobile multimedia devices is their conformance to well-known standards Cerqueira et al. (2008) (open application framework, standard interfaces, etc.) relieving end-users of the need to spend time learning proprietary technologies. By providing such design flexibility to end-users, software development on these platforms will be made much easier and more modular.

4. Challenges for future multimedia networks

In recent years, several solutions have been proposed in academic and industry environments regarding mobile multimedia networks assessment, content distribution, and optimization over heterogeneous wireless and wired networks and seamless multimedia mobility.

In future multimedia systems, new QoE-based application, transport and network levels optimization mechanisms (whether a cross-layer approach is used or not) are still needed, such as routing, inter/intra-session adaptation, resource reservation, traffic controller, seamless multimedia mobility and base station selection/user experience and IEEE 802.11k, v and r schemes mobility. Additionally, the multi-homing capability of current devices can also provide an improved performance for multimedia applications by taking advantage of the multiple connectivity levels of each wireless device.

4.1 Mobile multimedia systems

Seamless multimedia mobility will be one of the dominating factors for the success of next generation systems. Besides the basic connectivity needed by any type of application, multimedia applications have stringent requirements from the network, which include bounds on the end-to-end delay, loss rate, and delay jitter. Considering voice services: they commonly have generally low bandwidth requirements, which depend on the codec being used; but, on the other hand, voice is very sensitive to losses. Video services need a large amount of available bandwidth and compression is mandatory for such applications. While jitter and delay are still an issue, some losses are bearable due to the recovery capabilities of the compression mechanisms, such as MPEG-4. Overall, multimedia applications require that the quality of the communication has acceptable levels, which are naturally dependent on the nature of each application.

Due to the innate characteristics of wireless mobile technologies that have a limited capacity and are prone to interference, as well as to the challenges associated with mobility, the support of multimedia in such scenarios has raised work at several levels from, the technology dependent layers up to application adaptation, such as the compression mentioned before and base station selection.

The end-to-end support of multimedia applications requires the maintenance of the transmission quality level when multiple heterogeneous technologies are used and devices/users are mobile. One can imagine a Wireless LAN access and a WiMAX backhaul within a city scenario, a WiMAX access in rural areas with connection to some satellite or wired Internet access technology, or a train travelling across a country or between different countries. Besides the QoS capabilities of each technology, there is the need to guarantee an end-to-end quality level with QoE support.

Nowadays, mobility usually occurs between different access points, but within the same technology, which is known as horizontal handover. However, as devices become empowered with different technologies, which naturally vary in their quality and costing procedures, there is a need to develop mechanisms for handovers between different technologies, known as vertical handover. This situation raises the issue of inter-technology mobility, which poses additional challenges when multimedia applications are at stake.

4.2 Mobile scenario

The proposal of the scenario is based, Figure 8 shows on a mobility profile model, by forecasting the user centered path, and having as its main objective a resource reserve for multi-media traffic in WLAN networks. This scenario has as its intuition to present an analysis on the IEEE 802.11 technology utilizing some innovative concepts which combine the IEEE 802.11k,r and v mechanisms, having in view user mobility within a WLAN domain (BSS) and from this to minimize delays in the handover.

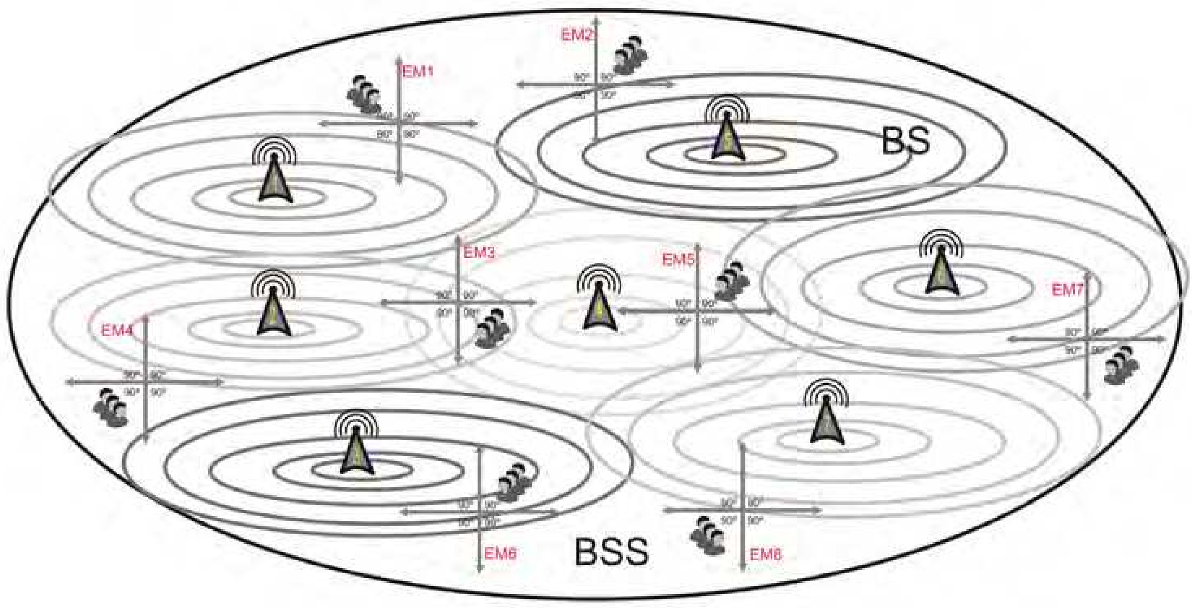

Fig. 8. Basic Scenario

4.2.1 Proposed model

The model seeks to minimize the reserve resource and in this way, maximize the resources for other EM mobiles in the domain. This model considers that 360° (degrees) of the possible direction of an EM mobile can be analyzed either in parts or in each of the four 90° (degree) quadrants and, in this way, can achieve the reserve resource in the neighboring APs of each quadrant, as can be illustrated as follows.

Taking account of the basic scenario of Figure 8, it is possible to observe a BSS with 7 Access Points (AP) and 8 Mobile Equipments (EP). A detailed description of the scheme can be undertaken for the analysis, by examining the AP2, AP4, EM3 and EM5 respectively.

The user of the EM3 is connected to the AP2 and in normal conditions, the reserve resource can be carried out in all the other 6 APs of the BSS, taking into account the fact that the user is able to follow the 360° (degrees) of the possible directions within the domain. Thus, by setting out with the proposed model and on the basis of the User Mobility Profile, (which was defined after the analysis of the k Standard Reports that identified the second quadrant [90°-180° degrees] as the probable path of the EM3), it can be stated that the AP2 is able to evaluate the neighboring APs within the coverage radius of the first quadrant, which are 5, 7 and 8 APs. It can also achieve the reserve resource for the EM5 which has one of the three APs as a prediction of the path.

In another analysis, the EM5 user is connected to the AP4 and in normal conditions, the reserve resource can also be carried out in all the other 6 APs of the BSS, by taking account of the 360° (degrees) possible direction that the user can follow within the domain. Thus, on the basis of the proposed model and taking the User Mobility Profile as a basis (which was defined after an analysis of the K Standard Report that identified the first quadrant [0°-90° degrees] as the probable path for the EM5), it can be considered that the AP4 is able to evaluate the neighboring APs within the coverage radius of the first quadrant (which are AP 5 and 6) and to achieve the reserve resource for the EM5 which has one of the two APs as the prediction of the path. After the reserve resource has been achieved in the determined APs, another process of great importance is initiated for multimedia traffic, which is related to the handover process. Figure 9 shows the handover concept in the IEEE 802.11k standard. When the STA configures the handover for the current AP, it evaluates its neighbors and makes a selection of the AP candidate through graphic or cache of the neighbor. A neighbor report is requested and soon after furnishes a response that finds and makes a selection of the AP. This model supplies the knowledge about the location of the neighboring APs.

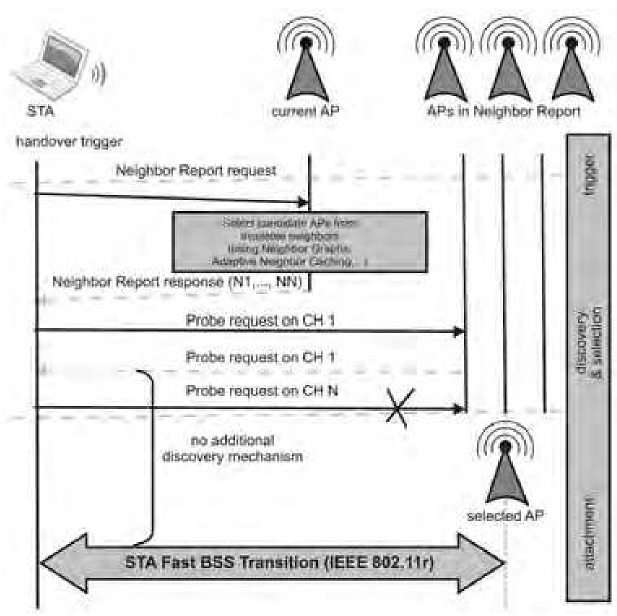

Fig. 9. The Handover Concept using IEEE 802.11k with neighbor reports

Figure 10 shows the concept handover based on neighbor reports and LCI (Location Configuration Information) . Position and velocity can be computed for each STA, which allows the exclusion of the neighboring APs from the list of candidates , thereby reducing latency in relation to the previous model. However, the 802.11k standard is not defined.

Managing BSS transactions in the IEEE 802.11v allows APs to set off handovers with a Management of BSS Transaction request at the specific moment, which is not defined by the IEEE 802.11v. This can happen automatically, or after being requested through checking on the management of the BSS Transaction of a STA. Figure 11 shows this mechanism in detail.

Figure 12 shows that in this mechanism there is an increase in functionality with the combination of the IEEE mechanisms 802.11k and 802.11v, although it uses IEEE802.11v through the management of BSS Transaction. Despite greater control of overload it forecasts the minimum of latency in the handover

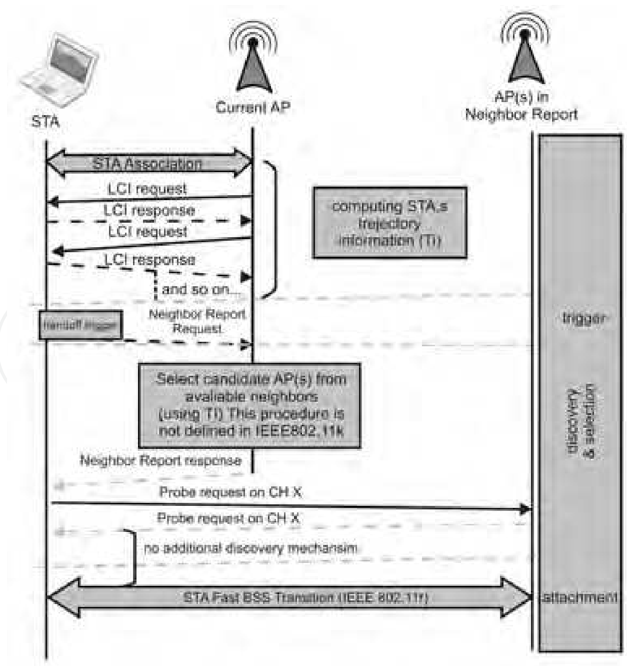

Fig. 10. Concept Handover using IEEE802.11k with neighbor reports and LCI

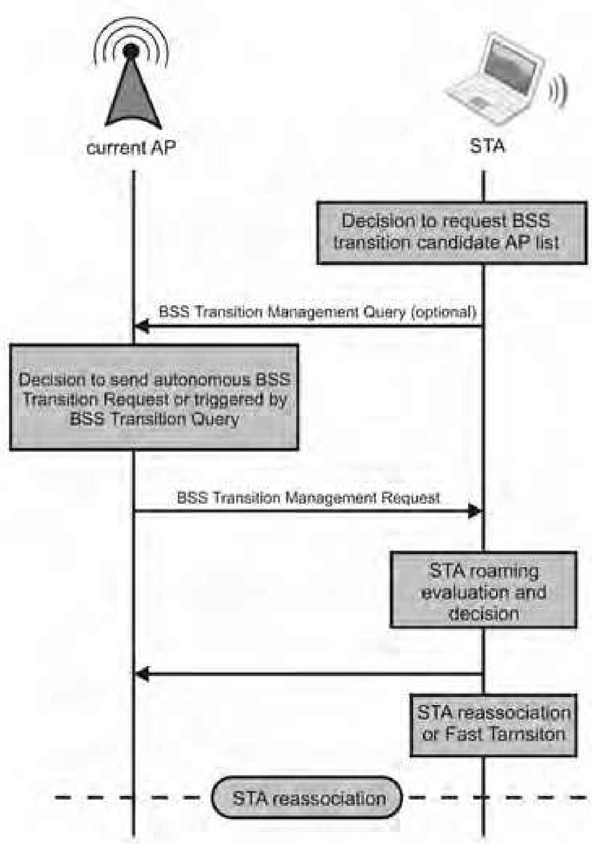

Fig. 11. Management of BSS Transaction IEEE 802.11v

After being collected, the information of the network APs of the mobility profile model with prediction of the user-centered path, will be define. The actual AP, where the user is

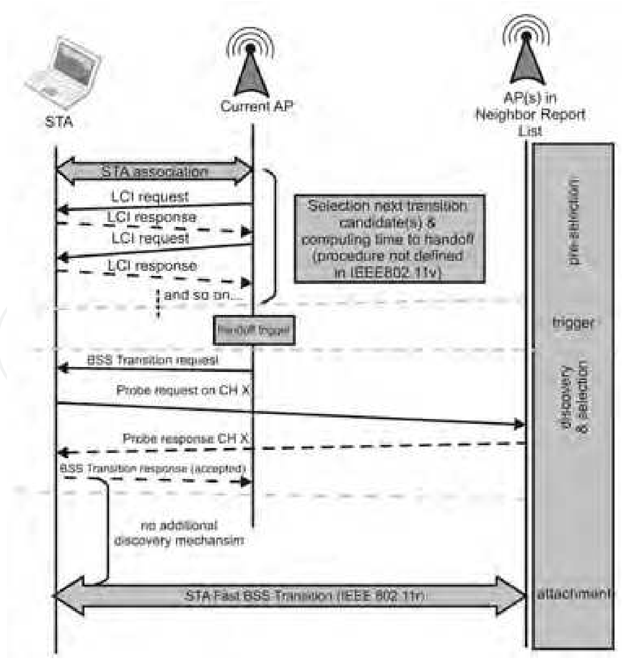

Fig. 12. The Handover Concept, using IEEE 802.11v with BSS Transaction Management and LCI

connected, will have a confidential relationship between the APs (Trusting AP and Trusted AP). Depending on the number and geographical location of the subscribers (STA), the reserve resources will be balanced, so that there can be no bias in the general performance of the network favoring handovers between neighboring APs.

5. Conclusions

Multimedia networks continue to be a strong research area, as it has been for more than a decade. This tendency should continue as the new challenges, such as the results of new services, mobility, novel portable devices, changes in user demands and terminals, network infra-structure, and heterogeneous devices arise. This chapter focuses on presenting important concepts of mobility based on IEEE 802.11k, v, and r. User-centric mobility models are required to allow seamless handover with QoE, including for high resolution multimedia such as 3D videos among others. This chapter has contributed to the understanding of the questions and challenges for the next generation of multimedia networks.

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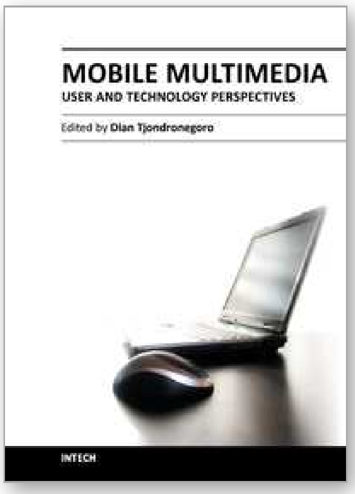

Mobile Multimedia - User and Technology Perspectives
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As multimedia-enabled mobile devices such as smart phones and tablets are becoming the day-to-day computing device of choice for users of all ages, everyone expects that all mobile multimedia applications and services should be as smooth and as high-quality as the desktop experience. The grand challenge in delivering multimedia to mobile devices using the Internet is to ensure the quality of experience that meets the users' expectations, within reasonable costs, while supporting heterogeneous platforms and wireless network conditions. This book aims to provide a holistic overview of the current and future technologies used for delivering high-quality mobile multimedia applications, while focusing on user experience as the key requirement. The book opens with a section dealing with the challenges in mobile video delivery as one of the most bandwidth-intensive media that requires smooth streaming and a user-centric strategy to ensure quality of experience. The second section addresses this challenge by introducing some important concepts for future mobile multimedia coding and the network technologies to deliver quality services. The last section combines the user and technology perspectives by demonstrating how user experience can be measured using case studies on urban community interfaces and Internet telephones.